APPEARANCE and DECAY of STRAWBERRIES, PEACHES, and LETTUCE TREATED WITH OZONE

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APPEARANCE AND DECAY OF STRAWBERRIES, PEACHES, AND LETTUCE TREATED WITH OZONE

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SUMMARY

The ozone concentration is reduced greatly in a chamber when it is loaded with wet blotting paper or with produce. The ozone concentration must be determined frequently to assure a fairly constant level.

Ozone did not reduce botrytis rot of strawberries in tests at temperatures of 55° to 60° F., relative humidity of 95 percent, and ozone concentrations of 0.1 to 10 parts per million (p.p.m.). The caps of strawberries dried and shriveled at ozone concentrations of 0.5 p.p.m. and higher.

Ozone in concentrations up to 10 p.p.m. had no commercially significant effect on the fungi causing rhizopus and brown rots of peaches at 60° temperature and 95 percent relative humidity; and no conclusive differences were obtained when peaches were held at ozone concentrations up to 0.7 p.p.m. at either 50° for 2 days or 36° for 7 days and then at 70° for 4 days in the air. At ozone concentrations above 0.5 p.p.m., injury to peaches appeared as brown sunken areas at the stomata, producing a pebbly effect.

At ozone concentrations of 0.5 p.p.m. and higher, the surface growth of mold on strawberries and peaches was inhibited.

At low concentrations of ozone, the outer leaves of head lettuce were injured.

REVIEW OF PROBLEM

The use of ozone is widely advertised as an aid in preserving food. As a result of this advertising, the number of inquiries received from the fruit, vegetable, and transportation industries concerning the effectiveness of ozone has greatly increased. The present study was undertaken to extend the information on ozone to commodities for which little information was available in the literature.

Ozone is formed when oxygen (O_2) molecules are split by electrical discharge releasing oxygen atoms which combine with molecular oxygen to form triatomic oxygen (O_3), an unstable gas with strong oxidizing properties. A monograph concerning ozone chemistry and technology was recently published by the American Chemical Society (*8*).[1] The germicidal properties of ozone led to its use, primarily in Europe, in disinfecting drinking water (*9*). Ozone has also been used to suppress mold growth on meats in meat-ripening rooms and on eggs in egg-storage rooms where high humidities promote fungal growth (*4*). Many claims have been made concerning the effectiveness of ozone in preserving fruits and vegetables. Ewell (*6*) claimed that fresh fruits such as strawberries, raspberries, currants, and grapes could be held twice as long in an atmosphere of 1.5 to 3 p.p.m. of ozone and delicate varieties of apples could be "carried several weeks beyond the normal storage period." Furthermore, the storage life of asparagus, beets, cabbage, carrots, cauliflower, cucumbers, kohlrabi, lettuce, radishes, and tomatoes is lengthened by adding 2 to 3 p.p.m. of ozone to the atmosphere. Unfortunately, Ewell did not present data to support these broad claims.

A considerable amount of data is available concerning the use of ozone in the storage of apples. Brooks, Cooley, and Fisher (*3*) reported that high ozone concentrations produce "brown dead spots" at the lenticels of apples. The work of Baker (*2*) did not reveal a beneficial effect of ozone on appearance, general condition, keeping quality, or flavor of stored Grimes and Stayman apples. Smock and Watson (*16*) reported that 0.6 p.p.m. of ozone would kill spores of *Penicillium expansum* Lk. ex Thom and *Monilinia fructicola* (Wint.) Honey on apple skin in 3 to 4 hours if the spores were not in clumps. The use of 1 to 2 p.p.m. of ozone an hour or two each day in the apple-storage room controlled the growth of surface mold and materially reduced the mold spore count of the rooms. Ozone at a continuous concentration of 1 to 2 p.p.m. did not prevent the rotting of McIntosh apples in

[1] Italic numbers in parentheses refer to Literature Cited, p. 11.

storage. Golden Delicious apples were more sensitive to ozone injury than the McIntosh apples, with injury appearing as a blackening of the skin at the lenticels. During a 5-month storage test at 1 to 2 p.p.m. of ozone, the natural wax of Rhode Island Greenings became sticky, but this condition almost disappeared when the apples were removed from storage.

The suggestion that ozone might inhibit storage scald in apples, together with the commercial claims of the beneficial effects of ozone in apple storage, led U.S. Department of Agriculture scientists to reinvestigate the problem thoroughly. The results published by Schomer and McColloch (*14*) indicated that the chief values of ozone in apple storage are "its maintenance of a pleasant atmosphere in the storage room and the control of surface molds on packages and walls." Ozone did not control decay and did not reduce the percentage of infected apples in inoculation tests. However, ozone did retard the rate of enlargement of infected areas. Scald was not controlled by ozone, but its development was reduced. At the concentration required to reduce scald (3.25 p.p.m.), the fruit was injured. Thus, although a few apple-storage houses still use ozone generators, there is little or no evidence to support their use.

Although ozone has been studied most extensively with apples, its possible use with other commodities has not been ignored. Barger and others (*1*) reported that ozone had no effect on the subsequent decay of California cantaloups exposed to concentrations of 20 p.p.m. for up to 9 hours at 70° F. Klotz (*11*) found that gassing with ozone for 16 hours did not protect Washington navel oranges from decay after injury and inoculation with spores of *Penicillium digitatum* Sacc. and *P. italicum* Wehmer. These results were confirmed and extended by Hopkins and Loucks (*10*), who reported that ozone not only failed to retard stem end rot or mold of Valencia oranges, but also in many cases increased the percentage of decay. Injury resembling that found on Golden Delicious apples was found by Smock and Watson (*16*) on Hale Haven peaches exposed to 5 p.p.m. of ozone at 40° for 2 weeks. DeHaas and Ewald (*5*) reported that 2 p.p.m. of ozone reduced the rot of acid cherries, strawberries, and red and black currants. However, since these workers stated that physiological decomposition was not retarded by ozone, it is possible that the internal changes were due to decay and that this concentration of ozone simply inhibited external growth of the fungus. Gane (*7*) reported that ozone could not "be fully circulated in a space filled with unripe bananas because of injury to the fruit." Thus, there appears to be little information in the literature that would encourage the use of ozone for the commercial storage of fruits and vegetables.

MATERIALS AND METHODS

Four stainless steel cabinets, each with a capacity of 6 cubic feet and equipped with individual compressors and thermostats, were employed as test chambers. Welsbach R2 ozonators were used to generate ozone. At first, an ozone generator was tried inside one of the chambers. The generator performed satisfactorily until the relative humidity was raised to about 95 percent as indicated on a hygrothermograph record. High humidity was obtained by flooding the bottom of the chamber with water and hanging lengths of wet cheesecloth from the shelves. The output of ozone was reduced sharply when the condenser plates were wet. Efficient production was obtained when the generator was placed inside a Scheibler desiccator (25 centimeter inside diameter) with a tubulated cover fitted with a rubber stopper through which tygon tubing for the air inlet and ozone outlet and the wiring for the ozonator could pass (fig. 1). The bottom of the desiccator was filled with calcium chloride ($CaCl_2$) to maintain a dry atmosphere, and a silica gel column was placed in the air line coming from the Gast heavy duty air pump, which maintained a flow of 2 liters per minute into the desiccator. Flow rates were measured with Brooks rotameters.

Ozone analysis was determined by the method of Saltzman and Gilbert (*13*). Samples of air for ozone analysis were withdrawn from test chambers at frequent intervals by using a portable pressure-vacuum air pump. Known volumes of air were collected in neutral buffered potassium iodide (KI) solution, which was then acidified with 2 drops of sulfuric acid (H_2SO_4) and allowed to stand for 10 minutes. The concentration of ozone was determined by reading the free iodine at 352 millimicrons (mμ) in a Bausch and Lomb Model 4 spectrophotometer. The ozone concentration could be raised or lowered by adjusting the variable transformer in the ozone generator circuit outside the desiccator. A voltage regulator was used to control fluctuations in line voltage.

Peaches and strawberries either were obtained locally from orchards or fields or were purchased at the wholesale market in Washington, D.C. Lettuce was obtained at the wholesale market. Although it was not necessary to inoculate strawberries with fungal spores, peaches were inoculated routinely with spores of the brown rot fungus (*Monilinia fructicola*) or the rhizopus rot fungus (*Rhizopus stolonifer* (Ehr. ex Fr.) Lind) im-

FIGURE 1.—General view of equipment table behind chamber used for studying commodities in ozone. The Welsbach R2 ozonators are inside the large desiccators, which contain calcium chloride ($CaCl_2$) in their bottom wells. A pump beneath the table delivers air at 2 liters per minute through a silica gel column through the Brooks rotameters to the desiccators. The portable pump is used to sample air in the chambers. The Bausch and Lomb Model 4 spectrophotometer in the foreground is used to analyze the ozone. Thermostats on the wall of the storage unit control individual chamber temperatures.

mediately before treatment, using procedures recommended by Smith, Haller, and McClure (*15*). Spores were obtained directly from the surfaces of peaches with rhizopus and brown rot. Heavy spore suspensions (about 200 spores per 100×—field of magnification) were prepared in beef-peptone broth containing 0.1 percent polyoxyethylene sorbitan monolaurate (Tween 20). Absorbent paper disks (Schleicher and Schuell No. 740–E) of one-half-inch diameter were added to the spore suspensions and allowed to soak for about 1 hour before they were placed on the face of numbered peaches. For *Monilinia fructicola*, the disks were placed on the uninjured surface, but for *Rhizopus stolonifer*, the disks were placed over a small wound made with either a fingernail or a scalpel stuck through a cork to simulate a fingernail wound.

RESULTS AND DISCUSSION

Relation of Load and Humidity to Ozone Concentration

In the first tests with fruit, the ozone concentration in the chamber was observed to drop to almost zero when the box was loaded. To obtain additional information on this phenomenon, the ozone concentration was tested at low and high humidities and with and without a load of blotting paper. The data presented in table 1 demonstrate that although high ozone concentrations are readily maintained in a dry atmosphere, high humidity can substantially reduce the ozone concentration in a cabinet and the presence of moisture-laden paper results in a drastic reduction of ozone. The output of the ozone generator must be adjusted until an equilibrium is obtained. In commercial practice, moist fiberboard produce containers could

greatly reduce ozone concentrations in a truck or railroad car.

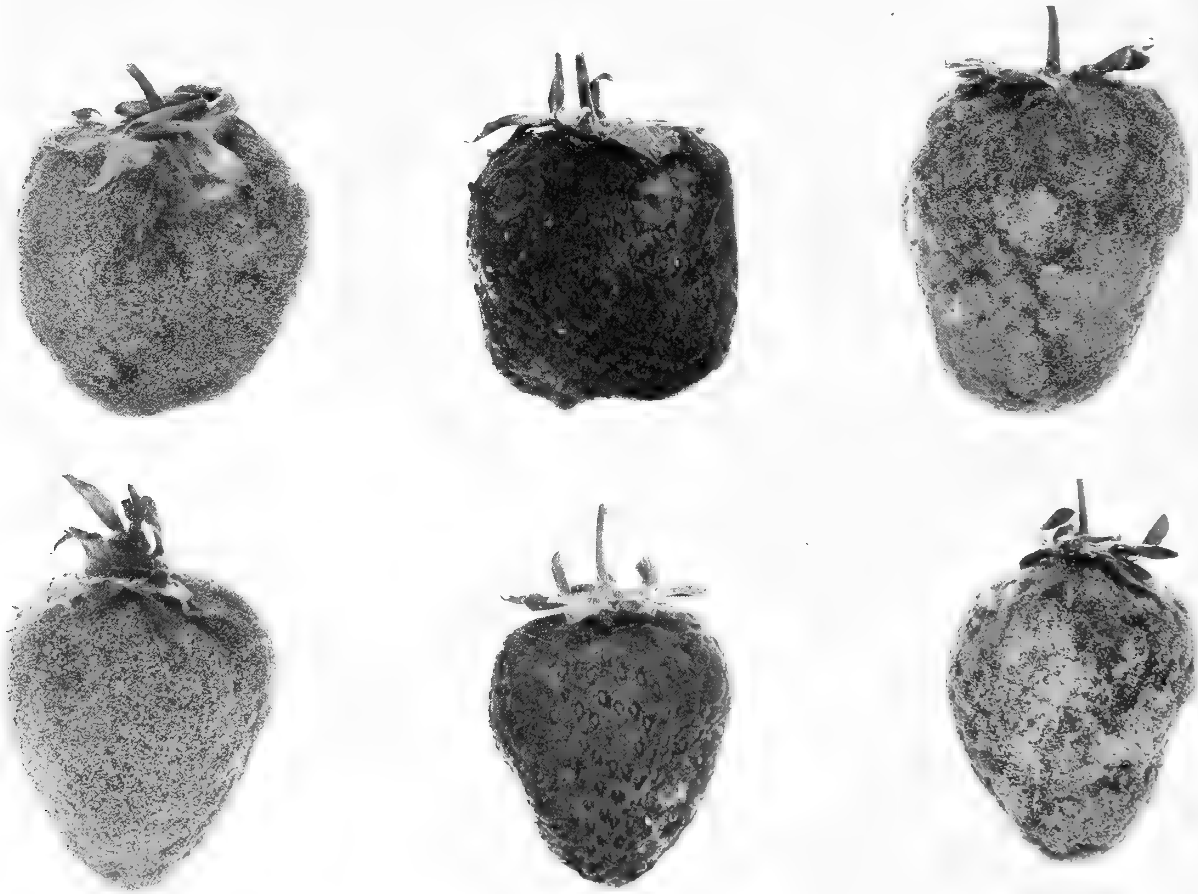
TABLE 1.—*Variation of ozone concentration with humidity and load*

Chamber load	Relative humidity	Ozone concentration
	Percent	*P.p.m.*
Calcium chloride (2 trays)	25	20.4
Calcium chloride (2 trays) plus paper[1] (3 trays)	25	16.4
Water (3 trays)	95	10.0
Water (3 trays) plus paper[1] (3 trays)	95	1.2

[1] 5-inch strips of dry blotting paper standing upright in a chicken-wire grid.

Decay of Strawberries Held in Ozone

Tests were made with strawberries (variety Z5–A) shipped by air from California and purchased at the wholesale market in Washington, D.C., and strawberries grown at the Plant Industry Station in Beltsville, Md. California strawberries usually contained considerable botrytis rot when purchased. Sound fruit was chosen at random and placed in soft polyethylene pint baskets. In tests at 55° F. (table 2) no differences were observed in the percentage of rotten strawberries when they were tested with and without ozone. The rot was almost exclusively due to *Botrytis cinerea* Pers. ex Fr. A striking difference was seen in the amount of aerial mycelia developing in the two treatments. Ozone at concentrations of 2 p.p.m. and above almost completely inhibited the develop-



A B C

FIGURE 2.—Influence of ozone on surface growth of *Botrytis cinerea* on strawberries: *A*, Strawberries showing abundant growth and sporulation of gray mold after being held in air for 6 days at 60° F. and 95 percent relative humidity; *B*, strawberries showing black leathery surface growth of fungus after being held under same conditions as *A* but with 5 p.p.m. of ozone added; *C*, strawberries showing heavy growth and sporulation after being held under same conditions as *B* for 5 days and then in air for 1 day at 70°.

TABLE 2.—*Effect of ozone on decay of strawberries (variety Z5–A) at 55° F. and 95 percent relative humidity*

Test No.	Treatment		Sound berries	Rotted berries	
	Time	Ozone		Aerial mycelia	No aerial mycelia
	Days	*P.p.m.*	*Percent*	*Percent*	*Percent*
1	5	0	3	36	61
	5	2	3	4	93
2	2	0	79	(1)	(1)
	2	5	74	(1)	(1)
	5	0	13	28	61
	5	5	11	0	89
3	3	0	51	(1)	(1)
	3	10	39	(1)	(1)
	5	0	3	46	51
	5	10	2	0	98

[1] Remaining berries in each test were rotted but not classified according to presence or absence of mycelia.

ment of aerial mycelia. These berries (fig. 2) were blackened in appearance. The black leathery growth is considered to be stromatic fungal tissue. That the fungus is not killed at these high ozone concentrations is shown by the rapid development of typical gray mold surface growth within 24 hours after the removal of the berries from the ozone atmosphere.

Since the California berries contained many advanced botrytis rot infections, the diameters of those infections without surface mycelium were measured and the berries were placed in trays and exposed to ozone at 55° F. Measurements made after 24 hours (table 3) indicate that the ozone had no penetrating effect and did not influence the internal spread of the fungus. External mycelial development was inhibited even at 0.5 p.p.m. of ozone.

TABLE 3.—*Effect of ozone on the spread of established areas of decay by* Botrytis cinerea *in California strawberries (variety Z5–A) at 55° F. and 90 percent relative humidity*

Ozone (p.p.m.)	Mean diameter of rotted areas—		Berries with surface mycelial growth
	At beginning of test	After 24 hours	
	Millimeters	*Millimeters*	*Percent*
0	11. 2	17. 9	16. 7
0. 5	12. 5	17. 8	0

Strawberries were picked in the field at Beltsville and placed in ozone storage immediately, on the assumption that they might react differently than the California strawberries, which were delayed several days before being exposed to ozone. In the first tests at 55° F. with varieties Surecrop and Sel. 3107, no rot developed in 7 days.

Subsequent tests with Surecrop, Sel. 3107, and Vesper were run at 60° to assure the rapid growth of fungi. Althought no effect of ozone was noted in Surecrop berries exposed to 0.1 and 0.6 p.p.m. of ozone (table 4), the higher concentration appeared to increase slightly the amount of rot in Sel. 3107. No significant effect of ozone at 0.1 or 0.6 p.p.m. was observed in Vesper, but 5 p.p.m. inhibited

TABLE 4.—*Effect of ozone on freshly picked local strawberries at 60° F. and 95 percent relative humidity*

Test No.	Treatment		Variety	Sound berries	Rotted berries	
	Time	Ozone			Aerial mycelia	No aerial mycelia
	Days	*P.p.m.*		*Percent*	*Percent*	*Percent*
1	6	0	Surecrop	32. 6	18. 3	49. 1
	6	0. 1	do	32. 9	15. 6	51. 5
	6	0. 6	do	28. 8	19. 5	51. 7
2	6	0	Sel. 3107	26. 0	36. 0	38. 0
	6	0. 1	do	36. 0	19. 0	45. 0
	6	0. 6	do	14. 1	42. 4	43. 5
3	4	0	Vesper	29. 2	16. 7	54. 1
	4	0. 1	do	37. 5	4. 2	58. 3
	4	0. 6	do	43. 5	4. 3	52. 2
4	5	0	do	21. 3	8. 2	70. 5
	5	0. 1	do	20. 6	11. 1	68. 3
	5	5. 0	do	23. 0	0	77. 0

aerial mycelial development without reducing the percentage of rot. The other differences were within the range of experimental error.

Ozone Injury to Strawberries

The flesh of the strawberries did not appear injured by ozone concentrations up to 10 p.p.m. administered for 5 days. However, at concentrations of 0.5 to 10 p.p.m., ozone caused shriveling and drying of the caps. This condition was not noticed at concentrations below 0.5 p.p.m. and would not be a problem at the concentrations (0.02 to 0.05 p.p.m.) now recommended by some manufacturers and distributors of ozonators.

Growth of *Rhizopus stolonifer* and *Monilinia fructicola* in Peaches in Ozone

Peaches were inoculated with disks impregnated with spores of either the rhizopus rot or the brown rot fungus. The disks were remoistened after 24 hours and infections were sufficiently advanced after 48 hours to allow removal of disks. Measurements of the diameters of the infections were made with a plastic ruler graduated in millimeters. Growth could readily be followed for several days or until most of the peach surface had been invaded by the fungus. Under these conditions ozone did not significantly retard the growth of either *Rhizopus stolonifer* or *Monilinia fructicola* (table 5) until a concentration of at least 0.5 p.p.m. was used. This retardation of growth is similar to that observed on apples stored in ozone (*14*). Increasing the ozone concentration to 10 p.p.m. did not appear to increase the degree of inhibition of fungal spread through the peach tissue, but did affect more markedly the surface growth of the fungi.

In tests with peaches held for 6 days at 60° F. and 95 percent relative humidity, ozone at concentrations of about 0.05 p.p.m. did not visibly affect the surface growth of either the fungus *Monilinia fructicola* or *Rhizopus stolonifer*. However, ozone at a concentration of 0.1 p.p.m. definitely changed the surface growth, especially that of *Monilinia fructicola*, the brown rot fungus (fig. 3) in which the growth became thick and spongy.

In another comparison of peaches held for 6 days at 60° F. and 95 percent relative humidity, ozone at concentrations of 0.5 p.p.m. and higher inhibited the fungal surface growth (fig. 4). That the fungus is not killed is shown by the rapid growth and sporulation that occurred when the peach was removed from the ozone after 5 days.

In brown rot of peaches, the subepidermal layer of fungal growth normally produces hyphae that arise in dusty tufts of conidiophores and conidia (*17*). Since the hyphae in the tissue are not killed by ozone, they continue to grow and push through

TABLE 5.—*Effect of ozone on the growth of* Rhizopus stolonifer *and* Monilina fructicola *in peaches at 60° F. and 95 percent relative humidity*

Test No.	Variety	Ozone	Mean growth of *Rhizopus stolonifer* in—					Mean growth of *Monilinia fructicola* in—				
			2 days	3 days	4 days	5 days	6 days	2 days	3 days	4 days	5 days	6 days
		P.p.m.	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*	*Mm.*
1	Dixie Red	0	------	19	37	69	------	------	20	31	54	------
	do	0.05	------	19	41	68	------	------	24	37	59	------
2	Early Red Free	0	15	33	63	96	132	16	28	43	60	74
	do	0.04	20	42	73	109	145	20	34	49	65	79
	do	0.9	14	21	48	72	96	12	20	32	44	56
3	Early Red Free	0	16	32	64	95	128	22	37	53	68	81
	do	0.09	16	32	64	96	138	18	31	46	62	78
	do	0.5	17	29	60	88	125	17	30	43	57	72
	Sun Haven	0	13	25	56	84	116	13	22	36	49	66
	do	0.09	14	28	58	89	125	15	24	34	49	69
	do	0.5	12	23	45	68	96	13	20	29	38	51
4	Red Haven	0	14	30	56	85	------	15	25	37	50	------
	do	5	13	21	46	68	------	10	17	28	38	------
5	Dixie Red	0	14	32	59	------	------	13	25	38	54	------
	do	10	14	23	52	------	------	13	22	32	41	------

[1] Each treatment reading represents the average diameter of the infected area for 15 peaches.

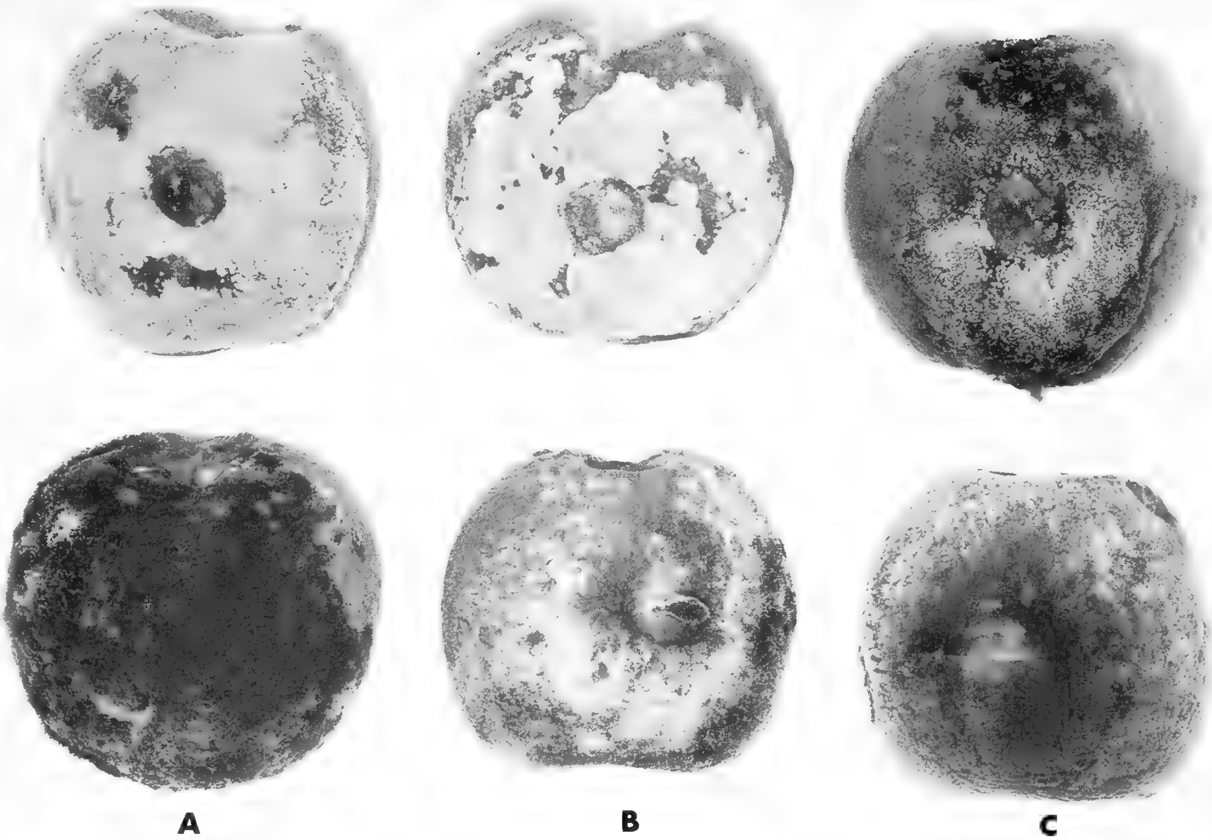


FIGURE 3.—Influence of ozone on surface growth of the fungi *Monilinia fructicola* (top row) and *Rhizopus stolonifer* (bottom row) on peaches: *A*, Peaches held in air for 6 days at 60° F. and 95 percent relative humidity, showing powdery masses of *M. fructicola* spores and black sporangia of *R. stolonifer; B*, peaches held under same conditions as *A* but with 0.1 p.p.m. of ozone added, showing a thick spongy growth of *M. fructicola* but reduced sporulation, and showing a large number of stromatic bodies but a reduced number of *R. stolonifer* sporangia; *C*, peaches held under same conditions as *A* but with 0.5 p.p.m. of ozone added, showing, as a result of inhibited fungal surface growth, gray to black stromatic bodies of *M. fructicola* and white bodies of *R. stolonifer* wherever the fungal mycelia grew through the skin.

the surface of the skin. At this point, the hyphae encounter a highly unfavorable atmosphere which inhibits normal development. The continued subepidermal growth and pressure result in mounds of stromatic tissue developing in tight blackened mounds on the peach surface (fig. 5). Once such peaches are removed from ozone, however, the stromatic tissue develops the typical mycelium with conidiophores and conidia in 24 hours. The response to ozone of rhizopus rot of peaches is similar to the response of brown rot except that the stromatic bodies appear as small white masses that darken with age.

Two transit conditions were simulated. In the first test, peaches were held at 0.2 and 0.7 p.p.m. of ozone for 2 days at 50° F., followed by 4 days at 70°. In the second test, peaches were held for 7 days at 36°, followed by 4 days at 70°. No conclusive results in control of rhizopus and brown rots were observed.

Ozone Injury to Peaches

Ozone injury to peaches has been reported previously (*16*) but the symptoms were not illustrated and only one concentration of ozone was reported. In the present study, ozone injury to peaches became obvious to the naked eye after 5 days at 10 p.p.m. of ozone. Sunken and browned tissue in the region of the stomata where ozone had caused death of tissue and loss of moisture gave injured peaches a pebbly appearance (fig. 6). Although injury was still evident at lower con-

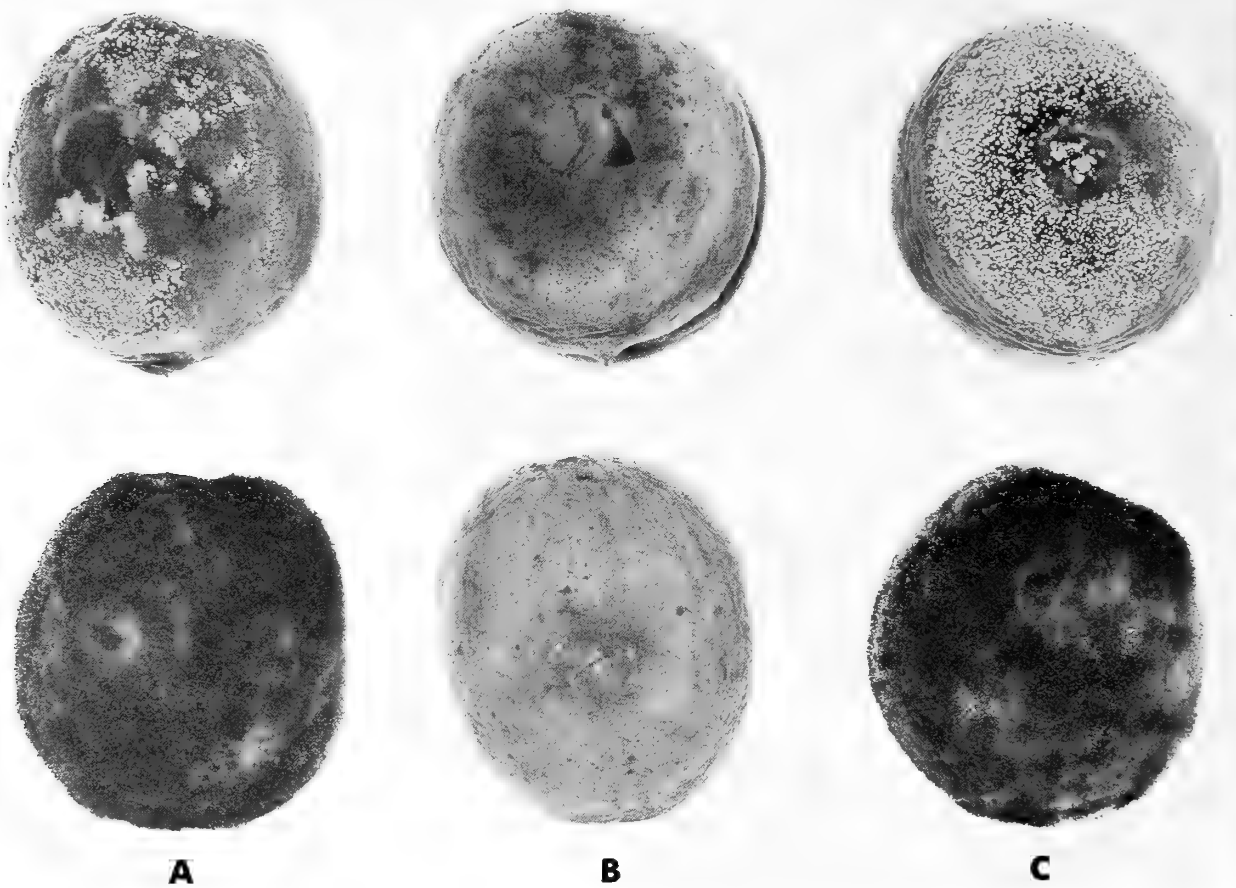


FIGURE 4.—Influence of ozone on surface growth of the fungi *Monilinia fructicola* (top row) and *Rhizopus stolonifer* (bottom row) on peaches: *A*, Peaches held in air for 6 days at 60° F. and 95 percent relative humidity, showing powdery masses of *M. fructicola* spores and black sporangia of *R. stolonifer; B*, peaches held under same conditions as *A* but with 0.5 p.p.m. of ozone added, showing inhibition of fungal surface growth; *C*, peaches held under same conditions as *B* but removed from ozone after 5 days and placed at 70° F. for 1 day, showing heavy fungal surface growth.

centrations (brown freckling of peaches was observed at 0.9 p.p.m.), little or no injury was detected at 0.5 p.p.m. and lower.

Ozone Injury to Lettuce

Ozone in the atmosphere can cause serious damage to plants in the field (*12*). In postharvest studies, we have found that as little as 0.04 to 0.06 p.p.m. of ozone will eventually produce toxic symptoms in the outer leaves of head lettuce stored at 36° F. and high relative humidity (about 90 percent). Lettuce exposed to this concentration for only 1 day did not develop symptoms when held for 8 days under identical conditions but without ozone. Exposure to this concentration of ozone resulted in increasingly severe injury in tests running from 2 to 8 days. Symptoms were not visible until the fifth or sixth day. The injury appeared as slight to moderate yellowing of exposed leaf surfaces and browning of intravascular areas. Brown flecking injury was found on some heads. Injury after 8 days in the low ozone concentrations was severe, with slight flecking of midribs appearing by the ninth day of storage.

In tests at higher concentrations of ozone, symptoms appeared sooner. Lettuce exposed to 0.1 p.p.m. of ozone for 4 hours did not show any injury after 4 days in the control chamber. After 1 and 2 days in ozone, head lettuce showed no injury on removal, but flecking of the midribs was evident on the third day. After 3 days in ozone, head lettuce showed flecking injury to ribs and midribs of exposed leaves and a yellowing of interveinal tis-

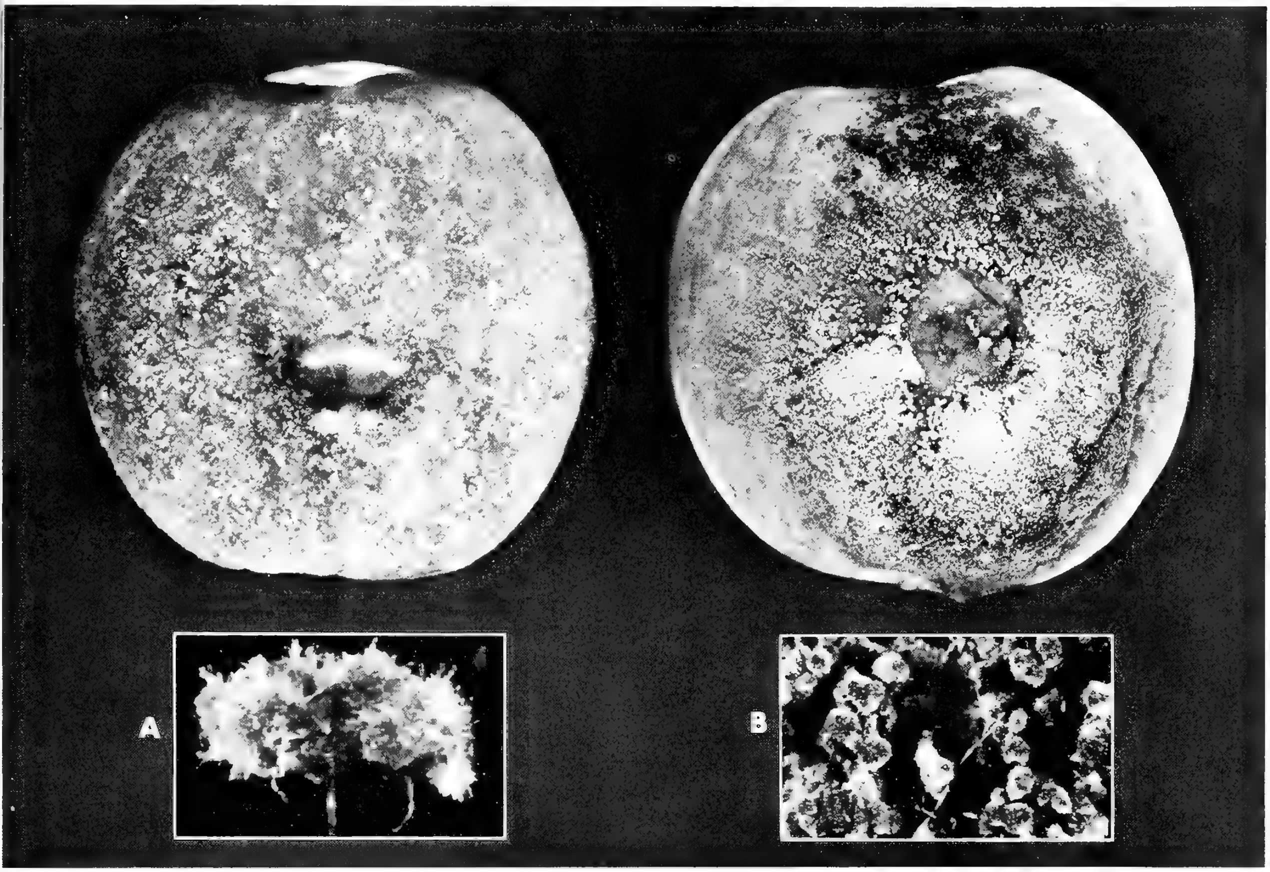


FIGURE 5.—Influence of 0.5 p.p.m. of ozone on the normal growth habit of the fungi *Rhizopus stolonifer* and *Monilinia fructicola* on peaches held for 6 days at 60° F. and 95 percent relative humidity: *A*, Peach covered with white stromatic bodies of *R. stolonifer*; *B*, peach with numerous gray to black stromatic bodies of *M. fructicola*. Greater detail is shown in the microscopic view below each peach.

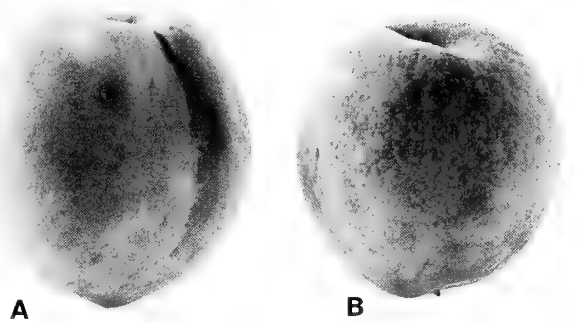


FIGURE 6.—Ozone injury to Dixie Red peaches: *A*, Peach held for 5 days at 60° F. and 95 percent relative humidity; *B*, peach showing injury after being held under same conditions as *A* but with 10 p.p.m. of ozone added.

sue. After 4 days, outer leaves were severely injured. Symptoms were the same as for 3 days' exposure to ozone but were more pronounced and also included browning of veins.

Ozone at 0.3 p.p.m. produced injury after only 5 hours, but the injury was not visible for 2 days. After 2 days in ozone, lettuce outer leaves showed severe water-soaking of the tissues. After 3 days, the water-soaked zones became confluent and the tissues were becoming yellow. After 4 days, the outer leaf tissues were severely injured with yellowing and increasing transparency of tissue.

At 0.3 to 0.5 p.p.m. of ozone, all exposed leaf areas were severely damaged in 4 days (fig. 7); and at 1 p.p.m., damage was severe within 3 days. Storage of lettuce in ozone would, therefore, be very risky.

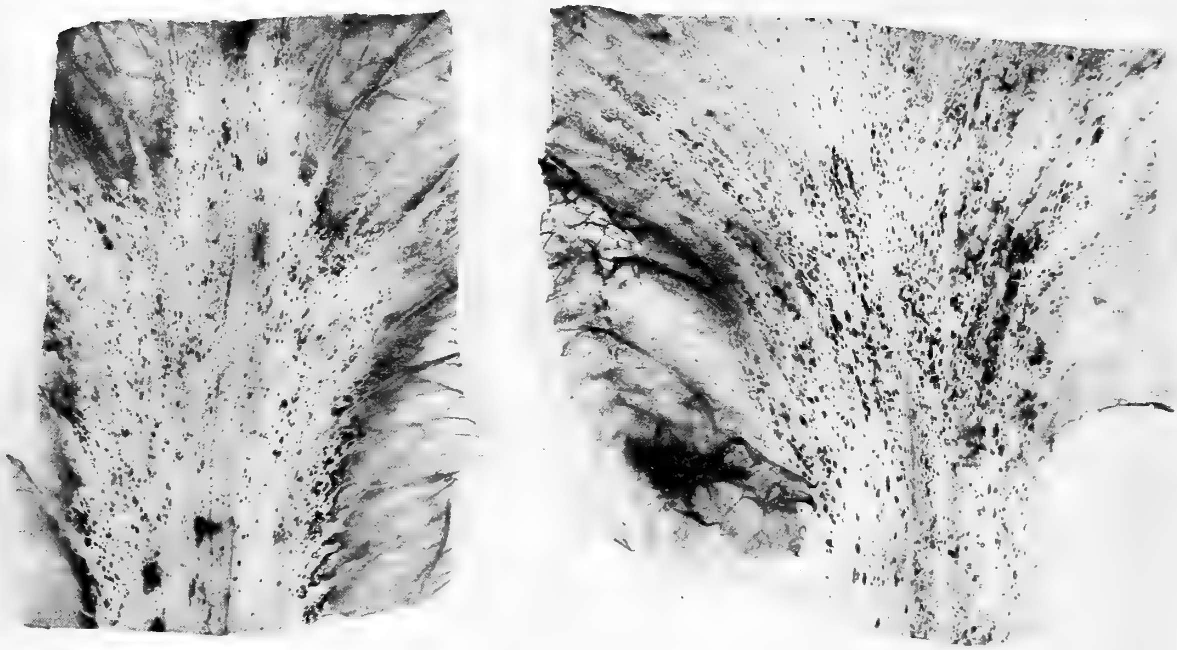


FIGURE 7.—Ozone injury to lettuce: Sections removed from outer leaves of head lettuce held at 0.5 p.p.m of ozone for 4 days at 38° F. and 95 percent relative humidity, showing the flecking of the midribs and the transparency of the interveinal tissue.

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